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Field Infestation by Insects That Injure Rice in Storage

By W. A. Douglas, *assistant entomologist, Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine*

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INTRODUCTION

Insects that injure stored rice have been a problem in the Southern States ever since rice culture began in that region. The system of handling the crop makes it necessary to hold the rice in storage for periods of from 3 months to over a year, and during this time the insect populations in it often increase to enormous numbers. Throughout the rice-growing area warehouses have been constructed for the storage of great volumes of both rough and clean rice with little or no regard for their suitability for fumigation of the stored grain. Not only is effective fumigation of these warehouses impractical, but conditions in them are very favorable for the rapid multiplication of the insects already present in the rice at time of storage. This infestation brought in from the field is thus of prime importance. Warehouse operators state that 10-percent loss in weight is caused by insects when infested rough rice is stored in November and held until the following June, and that the loss may amount to as much as 40 percent if the rice is held over into the second harvest year.

The three principal sources of infestation are field, warehouse, and mill. If rice free from any field infestation could be stored in clean warehouses sufficiently distant from other sources of infestation, there should be little loss from insects before it reaches the mill. Since the importance of the warehouse and the mill as sources of infestation has been carefully studied by many workers, this circular deals only with studies, made from 1934 to 1937, inclusive, to determine the importance of various sources of field infestation.

SPECIES OF INSECTS INVOLVED

A large variety of insects attack rice in storage and the following lists of those found to date in stored rice are believed to be complete:[1]

IMPORTANT INSECTS FOUND IN ROUGH RICE, IN THE ORDER OF THEIR IMPORTANCE

Angoumois grain moth (*Sitotroga cerealella* (Oliv.)).
Rice weevil (*Sitophilus oryza* (L.)).
Lesser grain borer (*Rhizopertha dominica* (F.)).
Cadelle (*Tenebroides mauritanicus* (L.)).

IMPORTANT INSECTS FOUND IN CLEANED RICE, IN THE ORDER OF THEIR IMPORTANCE

Saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)).
Cadelle.
Red flour beetle (*Tribolium castaneum* (Hbst.)).
Rice weevil.
Rice moth (*Corcyra cephalonica* (Staint.))
Indian-meal moth (*Plodia interpunctella* (Hbn.)).

SPECIES OF INSECTS OF MINOR IMPORTANCE FOUND IN STORED RICE AND RICE BY-PRODUCTS

Square-necked grain beetle (*Cathartus quadricollis* (Guer.)).
Siamese grain beetle (*Lophocateres pusillus* (Klug)).
Flat grain beetle (*Laemophloeus minutus* (Oliv.)).
Confused flour beetle (*Tribolium confusum* J. du V.).
Small-eyed flour beetle (*Palorus ratzeburgi* Wissm.).
Black carpet beetle (*Attagenus piceus* (Oliv.)).
Long-headed flour beetle (*Latheticus oryzae* Waterh.).
Broad-horned flour beetle (*Gnathocerus cornutus* (F.)).
Corn sap beetle (*Carpophilus dimidiatus* (F.)).
Larger cabinet beetle (*Trogoderma versicolor* (Creutz.)).
Lesser mealworm (*Alphitobius diaperinus* (Panz.)).
Varied carpet beetle (*Anthrenus verbasci* (L.)).
Thaumaphrastus karanisensis Blaisdell (a blind beetle).
Murmidius ovalis Beck.
Psocids.
Carpophilus nitens Fall.
Stelidota geminata (Say).
Chelifer cancroides (L.) (predator).
Chaetospila elegans (Westw.) (parasite).
Pteromalid (parasite).
Xylocoris cursitans (Fallen) (predator).

The Angoumois grain moth ranks first in importance as an insect injurious to stored rough rice and the rice weevil ranks second. The elimination or reduction in abundance of these two insects in stored rice would be of marked benefit to farmers, warehousemen, and millers.

SOURCES OF FIELD INFESTATION

Samples of rough rice were taken from shocks in fields in southwestern Louisiana about 10 days after the rice was cut and shocked, at different distances from probable sources of infestation as shown in table 1. Each sample was obtained by taking grain from three shocks at each location, threshing it immediately, mixing the resulting rough rice, and placing one-half pound of it in a sealed pint jar. The samples were then stored in a laboratory and examined at 3-week intervals until sufficient time had elapsed for complete emergency of the primary infestation.

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[1] These lists were drawn up by August I. Balzer of the Beaumont, Tex., laboratory of the Bureau of Entomology and Plant Quarantine.

Table 1.—*Infestation in rice in fields adjacent to various sources of infestation in southwestern Louisiana*

Distance from source	Infested samples in—					Samples		Samples infested by—		
	1934	1935	1936	1937	Total	Total	Infested	*Sitotroga cerealella*	*Laemophloeus minutus*	*Sitophilus oryza*
RICE WAREHOUSE AS PROBABLE SOURCE OF INFESTATION [1]										
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Pct.*	*No.*	*No.*	*No.*
Nearest point	9	2	2	1	14	19	74	10	5	3
50 feet farther		1	2	2	5	9	56	4	2	0
100 feet farther	8	1	2	2	13	19	68	10	3	1
200 feet farther	3	2	1	0	6	19	32	6	0	0
400 feet farther		1	1	1	3	9	33	2	1	0
Center of field		2	2	0	4	9	44	4	0	0
STACK OF RICE STRAW AS PROBABLE SOURCE OF INFESTATION [2]										
Nearest point	6	4	3	4	17	25	68	13	6	2
50 feet farther		3	4	2	9	15	60	6	5	2
100 feet farther	9	3	1	2	15	25	60	8	4	2
200 feet farther	3	2	2	3	10	25	40	9	1	0
400 feet farther		3	1	4	8	15	53	8	0	0
Center of field		1	1	0	2	15	13	2	0	0
CORN AND SORGHUM AS PROBABLE SOURCE OF INFESTATION [2]										
Nearest point	6	4	3	3	16	25	64	7	8	1
50 feet farther		2	4	2	8	15	53	7	2	0
100 feet farther	3	1	2	1	7	25	28	8	2	0
200 feet farther	2	2	0	0	4	25	16	4	0	0
400 feet farther		2	0	1	3	15	20	2	1	0
Center of field		3	0	0	3	15	20	3	0	0
WOODLAND AS PROBABLE SOURCE OF INFESTATION [2]										
Nearest point	4	2	1	2	9	25	36	5	4	1
50 feet farther		2	3	3	5	15	33	2	3	1
100 feet farther	4	1	1	2	8	25	32	6	3	0
200 feet farther	3	1	2	0	6	25	24	5	1	0
400 feet farther		0	1	3	4	15	27	4	0	0
Center of field		0	1	1	2	15	13	2	0	0
CHECK FIELDS ONE-HALF MILE OR MORE FROM ANY OF THE PRECEDING SOURCES [2]										
At edge	5	2	1	0	8	25	32	5	2	1
50 feet in		0	3	1	4	15	27	4	0	0
100 feet in	2	1	0	1	4	25	16	4	0	0
200 feet in	3	0	0	1	4	25	16	4	1	0
400 feet in		1	2	1	4	15	27	4	0	0
Center of field		1	1	0	2	15	13	2	0	0

[1] Number of fields: 10 in 1934, 5 in 1935, 2 in 1936 and 1937, or a total of 19.
[2] Number of fields: 10 in 1934, 5 in 1935, 1936, and 1937, or a total of 25.

In 1934 it was planned to examine 10 fields near each of the sources of infestation, single samples being taken at points nearest the source and additional samples at distances of 100 and 200 feet from this first sample point. It was impossible to find 10 fields at uniform distances from the typical sources of infestation. The nearest point in these fields in 1934 ranged from 6 to 556 feet from the source, but a majority of the nearest-point samples were within 75 feet of the source. Nearest-point samples collected in 1935-37 averaged within 50 feet of the source of infestation (fig. 1).

The data of table 1 are summarized in table 2, with the addition of the numbers of insects taken from the samples and the number of species represented.

The importance of warehouses and old strawstacks as sources of infestation may be seen from tables 1 and 2. The percentage of infested samples taken from fields adjacent to these sources was high and large numbers of insects emerged from these samples. Also, one more species emerged from samples collected near warehouses and two more species from samples collected near strawstacks than from samples that were collected in check fields or fields adjacent to corn, sorghum, or woodlands. Although corn and sorghum fields are sources of some rice-field infestation, the small acreage of these crops grown in the rice-producing area makes them of minor importance.

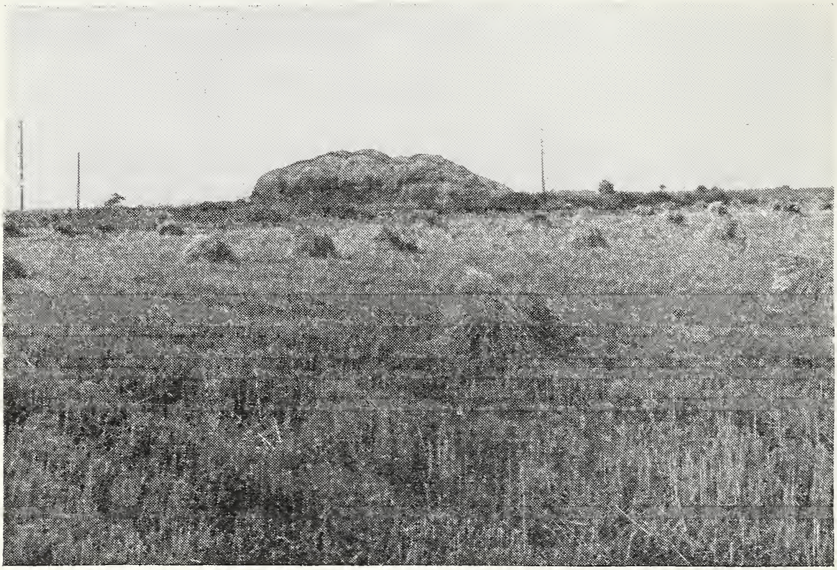

FIGURE 1.—Typical rice field with a strawstack near at hand which provided a source of infestation by rice insects.

TABLE 2.—*Summary of table 1 and data on insect emergence in storage from the samples of shocked rice collected near various sources of field infestation*

Source of infestation	Samples	Samples infested		Insects emerged	Species found
	Number	*Number*	*Percent*	*Number*	*Number*
Warehouse	84	45	53. 6	115	4
Strawstack	120	61	50. 8	129	5
Corn and sorghum	120	41	34. 2	60	3
Woodland	120	34	28. 3	65	3
Check	120	26	21. 7	36	3

STRAWSTACK-POPULATION STUDIES

Wedge-shaped samples of rice straw were cut out of stacks from the previous year's crop in southwestern Louisiana by using a section cutter which penetrated 4 feet into the stack. Straw was thus collected from a large number of stacks and weighed, and the grain carefully picked out of 1-pound samples of straw and stored in tin salve boxes for insect emergence. It was found that an average of 19 pounds of rice grain per ton of straw go through the thresher and into the stack. According to published records [2] there is an average of slightly more than a ton of straw per acre in commercial fields of Blue Rose rice. Table 3 gives results of insect emergence from rice grain handled as described above. On the basis of these figures over 100,000 insects might emerge from each ton of straw left in the stacks.

Table 3.—*Number of stored-rice insects emerging from grain taken from rice straw-stacks in southwestern Louisiana*

Year	Stacks sampled	Grain recovered	Insects emerged						
			Sitotroga cerealella	*Laemophloeus minutus*	*Sitophilus oryza*	*Cathartus quadricollis*	*Tribolium confusum*	*Rhizopertha dominica*	Total
	Number	*Ounces*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1934	15	4.1	388	203	9	1	0	0	601
1935	21	6.1	1,721	1,533	27	4	1	1	3,287
1936	6	1.1	377	40	0	0	0	0	417

OTHER HOST PLANTS OF STORED-RICE INSECTS

Seeds of *Paspalum urvillei* Steud., *Echinochloa crusgalli* Beauv., and *Eleusine indica* Gaertn. and of several other grasses were collected and held for observation, but no insects emerged. Insects did emerge, however, from red rice, a variety of *Oryza sativa* L. which is a very common and serious weed in commercial rice fields. Acorns were collected near rice fields, but no insects that attack stored rice emerged from these. Observations were made on corn and various species of grain sorghums, and from these numerous Angoumois grain moths and rice weevils emerged.

VARIETAL PREFERENCE IN THE FIELD

Shocks in the varietal test plots at the Rice Experiment Station at Crowley, La., were examined, and half-pound samples of rough rice were taken from each of three replications of each variety and held in sealed glass jars for insect emergence. This rice was grown within one-half of a mile of considerable quantities of stored rice and mule feed, and corn and sorghum fields. A very high percentage of field infestation was recorded. Out of 225 samples collected, 125, or 55.5 percent, developed infestations. Data on the emergence of stored-rice insects from variety samples are given in table 4.

An analysis of variance in the data for the 14 varieties from which samples were collected in all 4 years showed that there was no significant difference in infestation among varieties, but that the difference in infestations between the years was highly significant, the odds being greater than 99 to 1.

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[2] Chambliss, Charles E., and Jenkins, J. Mitchell. some new varieties of rice. U. S. Dept. Agr. Bul. 1127, 18 pp., illus. 1923.

TABLE 4.—*Infestation by stored-rice insects in the varietal test plots at Crowley, La., as revealed by three half-pound samples from each variety*

Variety of rice	Samples infested in—				Total	Infestation
	1934	1935	1936	1937		
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*
Iola	3	3	1	3	10	83.3
Wataribune	2	1	3	3	9	75.0
Caloro	3	0	3	3	9	75.0
Nira	3	2	1	3	9	75.0
Lady Wright	3	1	2	2	8	66.6
Acadia	2	1	2	2	7	58.3
Delitus	3	2	0	2	7	58.3
Early Prolific	3	2	0	2	7	58.3
Shoemed	2	2	2	1	7	58.3
Edith	2	2	1	1	6	50.0
Blue Rose	3	2	0	1	6	50.0
Vintula	3	1	1	1	6	50.0
Fortuna	1	2	0	1	4	33.3
Rexoro	3	1	0	3	7	58.3
C. I. No. 4191	2	1	2		5	55.5
Stormproof	3	1	1		5	55.5
Shinriki	2	1	0		3	33.3
Colusa	3	0	0		3	33.3
Honduras	3	1	1		5	55.5
Arkansas Early Blue Rose				1	1	33.3
Zenith				1	1	33.3
Latex				0	0	0
Wrights Early Blue Rose				0	0	0
Total	49	26	20	30	125	55.5

Considering only the 125 samples found infested in the varieties of rice shown in table 4, *Sitotroga cerealella* was found in by far the greatest numbers, being present in 117, or 93.6 percent, of the infested samples, *Sitophilus oryza* in 5.6 percent, and *Laemophloeus minutus* in 4.8 percent (table 5).

TABLE 5.—*Infestation of rice by three important insects as found in the 125 infested samples shown in table 4*

Year	Total infested samples	Samples infested by—		
		Sitotroga cerealella	*Sitophilus oryza*	*Laemophloeus minutus*
	Number	*Number*	*Number*	*Number*
1934	49	47	3	2
1935	26	23	1	1
1936	20	18	1	2
1937	30	29	2	1
Total	125	117	7	6
		Percent	*Percent*	*Percent*
Percent of total		93.6	5.6	4.8

EFFECT OF INSECT INJURY ON GERMINATION OF SEED

The effect of insect injury to seed rice was studied in two ways. Germination tests were made by the author of selected seeds that were known to be infested, and the seed-testing laboratory of the Bureau of Plant Industry at Washington, D. C., made tests of unselected grains from various lots of seed rice, all of which were infested, collected from various warehouses in southern Louisiana. In the first tests none of the seeds that showed emergence holes of the Angoumois grain moth germinated, whereas 92 percent of the sound seeds from the same samples germinated.

The samples collected from warehouses were divided into 2 sets, 1 set being held for insect emergence and the other being submitted to the seed-testing laboratory for germination tests. The results showed that an infestation of not more than 1,485 insects per bushel of seed rice, the number present in the most heavily infested samples, was of little or no importance from the standpoint of decreasing the germination. Up to that degree of infestation there was no correlation between the number of insects present and the percentage of germination. It is evident, however, from the germination tests made by the author with infested seeds, that infestations may build up to a point where definite losses in germination will result.

METHODS FOR DECREASING FIELD INFESTATION

Thorough Cleaning of Warehouses

It is very important that all old grain be cleaned out of all warehouses and storage places within 1 mile of rice fields and shipped or fed before the new crop heads. In these studies over 50 percent of the rice samples collected from fields near warehouses developed infestations of stored-rice insects. In fact, removal of old grain and thorough cleaning of warehouses is doubly important, (1) because the insects breeding in the warehouses are a source of infestation of grain in the field, and (2) because the insects, always extremely abundant, in uncleaned warehouses infest the new crop of rice as soon as it is stored in them.

Destruction of Old Strawstacks

The importance of old rice strawstacks as sources of infestation is shown by the fact that in these studies 50.8 percent of all samples collected from fields adjacent to strawstacks developed infestations. The general practice among rice farmers is to thresh the rice and leave a large strawstack in one location. Sound as well as infested seeds and kernels go through the thresher and into the stacks, where conditions are favorable for breeding of the insects. These stacks are left for cattle to feed on during the winter months, but in most cases tons of straw remain after grass is available in April and May, and the cattle leave this straw for green pastures. Strawstacks thus serve as breeding places for insects that infest rough rice in the field the next season.

Two methods of disposing of strawstacks are recommended. These are burning and spreading. Burning is preferable from the standpoint of insect control. Strawstacks should be burned in May or, at the latest, sometime before the new crop of rice begins to head, or they should be spread before the end of May. Straw has some value as fertilizer when spread on idle riceland, and the partly decomposed straw at the base of the strawstack is a very good fertilizer when spread on land to be planted in cultivated row crops such as cotton, corn, or sweetpotatoes. When the stacks are spread on land intended for cultivated crops and plowed under not later than May, very few insects and rice grains remain by the time the rice crop begins to head. When stacks are spread on idle riceland the seeds are exposed to birds and field mice, which destroy many of them. Many grains will sprout or rot from exposure to rainfall and sunlight and they are thus rendered unfit for insect breeding.

AVOIDANCE OF NEARBY CORN OR SORGHUM

In southern Louisiana the corn and sorghum crops mature early enough for a brood of stored-rice insects to mature in the corn ears and sorghum heads by the time the growing rice reaches the stage attractive to them. The data in tables 1 and 2 indicate that there is considerable spread of these insects into the rice fields from adjacent fields of corn or sorghum. Although corn and sorghum can be grown in the rice-producing area of Louisiana, they serve as breeding places for the Angoumois grain moth and the rice weevil, and corn in particular is usually damaged severely by the sugarcane borer (*Diatraea saccharalis* (F.)). For these reasons they are seldom profitable crops for the rice farmer and should not be grown in the immediate vicinity of rice fields.

SUMMARY

Conditions existing in rice storage warehouses in the South are not only favorable to the increase of insects attacking stored rice but are such as to make effective fumigation for the control of these insects almost impossible. The importance of storing unifested rice in an uninfested warehouse is thus apparent. The difficulty of controlling the insects after the grain is stored led to the present study of possible sources of field infestation and methods of reducing the numbers of insects already present in rough rice when it is put into storage. There are at least 25 insects that attack stored rice or rice products, and 8 of these cause serious losses.

This study has shown that the chief sources of field infestation of rice by insects attacking it in storage are, in the decreasing order of their importance, storage warehouses, strawstacks, and corn and sorghum fields.

Counts of representative samples indicate that there may be as many as 100,000 rice insects per ton of straw in the rice strawstacks.

No variety of rice is significantly resistant to insects that attack stored rice.

The insect populations usually found in stored rice do not seriously affect the germination of the seed.

Recommendations for reducing the number of insects taken into warehouses from the fields are (1) to clean warehouses thoroughly and dispose of all old grain before the new crop of rice heads, (2) to spread strawstacks on stubble fields if possible, or burn them, by the end of May after green pasture is available for the cattle that have been feeding on them, and (3) to avoid, if possible, planting corn or sorghum near rice fields.

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